CRUSTACEANS

Crayfish:
Northern crayfish *Orconectes virilis*
Louisiana crayfish *Procambarus clarkii*
Water nymph crayfish *Orconectes nais*
Rusty crayfish *Orconectes rusticus*
Utah is inhabited by a single native crayfish known as the Pilose crayfish *Pacifastacus (Hobbsastacus) gambelii*. Its native range is in northern Utah's Bear River, Weber River and Ogden River drainages and in the Raft River Mountain's drainages. Isolated populations, also, persist in Salt Creek, east of the Great Salt Lake. None of the invasive species of crayfish found in Utah are known to overlap its range (Figure 1). Crayfish are not native to the Colorado Plateau (Dean 1969) or to the Bonneville basin south of Utah County (Johnson 1986), including the Sevier River Drainage. Two other species of *Pacifastacus* are native to states adjoining Utah: *Pacifastacus leniusculus* in Nevada and *Pacifastacus (Hobbsastacus) connectens* in Idaho (Pennak 1978). Both may be native to Utah waters, however, this possibility has yet to be confirmed (Johnson 1986). The signal crayfish *Pacifastacus leniusculus* is present in Utah County, and may have been introduced there (Johnson 1986).

Unfortunately, two known invasive crayfish, the northern crayfish *Orconectes virilis*, and Louisiana crayfish *Procambarus clarkii* are found in Utah (Figure 1). These invasive crayfish are both considered AIS.

The water nymph crayfish *Orconectes nais* and the rusty crayfish *Orconectes rusticus* do not currently inhabit Utah, but each are AIS that threaten to arrive. *O.nais* has heavily infested Colorado waters, and due to its distribution on the western slope of Colorado, *O. nais* has potential to invade Utah waters. *O. rusticus* poses a threat due to its wide North American distribution. Both are popular among anglers as bait, which represents a pathway for potential movement to Utah. This document does not further address either of these two AIS, although management considerations are the same as those discussed for all crayfish.

Northern Crayfish *Orconectes virilis*
Distribution:
This AIS is found in association with Scofield Reservoir and the lower Price River; Huntington North Reservoir and lower Huntington Creek; Strawberry and Starvation Reservoir's lower Strawberry River and Duchesne River; Yellowstone River and Uinta River. It is also found along the full length of Lake Powell on the Colorado River, including the San Juan River arm. This crayfish inhabits the Santa Clara River and Virgin River, downstream into Arizona and Nevada, which discharges to the Colorado River. A limited population persists in New Castle Reservoir of Iron County, too. Limited populations persist in the Great Salt Lake Valley along the lower Ogden River and Weber River reaches. Another population persists in Tooele County's Grantsville Reservoir south of the Great Salt Lake. And, a limited population persists along the lower Provo

River between Deer Creek Reservoir and Utah Lake. The lower elevation distribution seemingly is limited by rising salinity levels in the water (Figure 1).

Louisiana crayfish *Procambarus clarkii*
Distribution: *P. clarkia* can be found in Tooele County's western basin drainage near St. John (Figure 1).

Pacific crayfish *Pacifastacus leniusculus*
Distribution: *P. leniusculus* is found in the Salem Pond and Spring Pond along the southeast side of Utah Lake between Santaquin and Payson (Figure 1).

Description: All of the crayfish look much alike, although there certainly are subtle differences in color hues. *P. leniusculus* seems to be the largest, reaching lengths of 12 to 16 cm; *O. virilis* reaches lengths of 10 to12 cm; and *P. clarkia* can grown to about 5.5 to 12 cm in length (Collicut 1998).

Ecology: Crayfish eat aquatic plants--they have been used to clear weeds from ponds on fish farms (Griffiths et al. 2004); invertebrates such as snails and insects; tadpoles and small fish. Generally, they are opportunistic omnivores, but they mostly obtain their food by scavenging dead animals and detritus. Crayfish can be cannibalistic or prey on individuals of other crayfish species (Ilhéu and Bernardo 1993, Guan and Wiles 1997, Nystrom 1999a and 1999b, Lewis 2002).

O. virilis can mate in autumn or in spring, but the eggs are not fertilized and laid until spring. Eggs are attached under the female's tail to swimmerets in a large ball resembling a raspberry, and they hatch one to two months after they are laid. Young hatchlings look like miniature adults and can probably grow to about 2-3 cm long by the fall. *O. virilis* has a short lifespan; males and females usually die when they are about 2 years old. Males dies after mating and females die after their young hatch. Occasionally they are known to live longer, but it's thought that none survive beyond their 4th spring (Collicut 1998).

P. clarkii has been known to incubate eggs or carry young throughout the year (Lindqvist and Huner 1999). This allows reproduction at the first available opportunity, which contributes to colonization success (Huner 1999, Gutierrez-Yurrita et.al. 1997, Gutierrez-Yurrita and Montes 1999). Newly hatched young remain with their mother in the burrow for up to eight weeks and undergo two moults before they can fend for themselves (Ackefors 1999). Breeding males are known to move up to 17 km in four days and cover a wide area, which helps dispersion (Barbaresi and Gherardi 2000). *P. clarkii* is able to tolerate dry periods of up to four months (Huner 1999, Ackefors 1999), and is able to occupy a wide variety of habitats, including subterranean situations, wet meadows, seasonally flooded swamps and marshes, and permanent lakes and streams. *P. clarkii* thrives in warm, shallow wetland ecosystems, including sluggish streams and lentic situations where low oxygen levels and high temperatures exist. It is one of few North American crayfish with tolerance for saline waters (NatureServe 2003).

P. leniusculus typically mates and lays eggs during October; hatching occurs from late March to the end of July depending on temperature. *P. leniusculus* occupies a wide range of habitats from small streams to large rivers and natural lakes, including sub-alpine lakes (Lowery and Holdich 1988, Lewis 2002). *P. leniusculus* also grows well in culture ponds, and it tolerates brackish water and high temperatures, but it does not occur in waters with a pH lower than 6.0. *P. leniusculus* is very active, migrating up and down rivers, however, its rate of colonization is relatively slow and may only be about 1 km/yr. This species can be very long lived, with specimens known to survive 16 to 20 years (Stebbing et al. 2003). Their burrows are known to have a serious impact on bank morphology, causing them to collapse (Guan 1994, Sibley 2000).

<u>Impacts</u>: Crayfish introductions can negatively impact ecosystems and cause economic damage. When crayfish are introduced into a suitable habitat it is typical that they become quickly established, and as a result dramatic changes occur in native plant and animal communities (Schleifstein and Fedili 2003). For example, *P. clarkii* has contributed to the decline of some native European crayfish by introducing interspecific competition pressure and acting as a vector for the transmission of the crayfish fungus plague *Aphanomyces astaci*. This crayfish has also been associated with the crayfish virus *vibriosis* in crayfish farms, and is an intermediate host for numerous helminth parasites of vertebrates (Thune et al. 1991; Holdich 1999; Holdich, Gydemo and Rogers 1999; Holdich, Rogers and Reynolds 1999). Bowen (2003) indicated that *O. rusticus* has a very high rate of metabolism, and it could potentially eat twice as much as *O. virilis*, damaging macrophyte populations. *O. rusticus* often displaces native crayfish species. *P. leniusculus* continues to spread in Great Britain, and may well cause the extinction of their single indigenous crayfish species within the next 30 years (Hiley 2003 and Sibley 2003). Nonnative crayfish infestations also reduce the functionality of freshwater habitats in which they become established by consuming invertebrates and macrophytes, and degrading river banks through burrowing activity (Holdich 1999). Potential negative effects of non-native crayfish include the following (Godfrey 2002):

- Competition for food and space with resultant displacement of native crayfish;
- Transfer of disease;
- Consumption of wild fish eggs with resultant reduction of fish stocks;
- Consumption of large amounts of macrophytes, having indirect and direct effects on other invertebrates;
- Clouding the water with suspended solids due to their digging and swimming activity, which reduces photosynthesis by macrophytes; and
- Destabilizing ditches, canals, and stream banks.

<u>Pathways For Invasion or Spread</u>:

- <u>Aquaculture</u> (Huner 1999, Washington Department of Fish and Wildlife 2003)
  Note[1]: *P. leniusculus* was first introduced into Japan from North America for use as food in 1928.
  Note[2]: Crayfish are harvested from natural waters by commercial fishers and cultivated in small earthen ponds from which they can escape or simply be introduced into other waters.

Note[3]: *P. clarkii* is a popular dining delicacy, accounting for the vast majority of crayfish commercially produced in the United States.

- Anglers
  Note[1]: Crayfish are popular among anglers as bait, allowing inadvertent spread.
  Note[2]: Crayfish are popular among anglers as a fun and tasty catchable food; so anglers purposely spread them to waters they desire to fish.
- Natural dispersal (Huner 1999, Nature Serve 2003, Washington Department of Fish and Wildlife 2003)
  Note[1]: *P. clarkii* as a bait for largemouth bass is believed to be causative for their introduction into the State of Washington.
  Note[2]: There are reports of migrations by male crayfish over several miles in comparatively dry areas, especially in the rainy season.
- Aquarium Trade (Huner 1999, Holdich 1999, Holdich, Gydemo and Rogers 1999, Holdich, Rogers and Reynolds 1999)
  Note[1]: Sales of live *P. clarkii* as an educational prop for teachers and students, as a aquarium or garden pond pet, or as food for predaceous aquarium fish may have accelerated their spread, especially due to aquarium dumps when an owner tires of the hobby or no longer has a use for the crayfish.
  Note[2]: The crayfish that now occur in African freshwaters are thought to have been introduced by smugglers without the knowledge and permission of the relevant authorities (Holdich 1999; Holdich, Gydemo and Rogers 1999; Holdich, Rogers and Reynolds 1999).

Management and Control:
The best method of control is to prevent their initial introduction.

Law enforcement efforts (legislation for effective laws and follow-up patrols) designed to prevent the spread of crayfish has proven difficult, since many people intentionally spread crayfish to enhance their recreational sport of cray-fishing. Educating anglers, aquarium sales staff, crayfish trappers, bait dealers, and teachers about the threats posed by invasive crayfish will help reduce the risk from expanding populations.

Possible control options include the elimination or reduction of introduced crayfish via mechanical, physical, chemical or biological methods. Treatments can be followed by the restocking of native crayfish populations, when feasible. And, research should consider the development of plague-resistant strains of native crayfish.

- Physical Methods: They include but are not limited to drying (draining of ponds and the diversion of flowing channels) and the construction of barriers (either physical or electrical) to preclude crayfish movement.
  Note[1]: Population reduction may be possible by physical methods, although eradication is unlikely unless the population is particularly restricted in range and size.
  Note[2]: Physical methods have environmental costs, which should be weighed against the environmental benefits of employing them.

- Mechanical methods: They include but are not limited to the use of traps, seine nets, and electro-fishing.
  Note[1]: Continued trapping is preferable to short-term intensive trapping, which may provoke feedback responses in the population such as stimulating a younger maturation age and greater egg production. Also, trapping is size selective, so the smaller individual crayfish remain, taking advantage of the lack of competition to grow rapidly (Sibley 2000).

- Chemical Methods: Biocides such as organophosphate, organochlorine, and pyrethroid insecticides can be used to control crayfish. Individual crayfish are differentially affected depending on their size, with smaller individuals being more susceptible. Another possible chemical solution lies in the potential to use pheromones to enhance trapping success of the AIS crayfish. To date, crayfish-specific or even crayfish species-specific chemical pheromones have yet to be developed, although this technique has been used to control insect populations (Pedigo 1989). Crustaceans do emit pheromones and Stebbing et al. (2003 and 2004) have researched the possibilities of using pheromones to attract male *P. leniusculus* into traps.
  Note[1]: Biocides are not crayfish-specific, so other invertebrates, such as native crayfish and other benthic organisms, may be eliminated along with the AIS crayfish. Re-stocking of target and non-target species needs to be considered.
  Note[2]: There is cause for concern about toxin bioaccumulation and biomagnification in the food chain when using chemical methods, although it is less of a problem with pyrethroids.

- Biological Methods: They include the use of fish predators, disease-causing organisms (that infect only crayfish) and use of microbes that produce toxins; for example the bacterium *Bacillus thuringiensis* var. *israeliensis*. (Holdich, Gydemo and Rogers 1999).
  Note[1]: Only the use of predaceous fish has been used successfully; eels, burbot, perch and pike are predators that are partial to eating crayfish. The amount of cover, type of fish predator used and AIS crayfish location are all important variables in determining the success of such an approach. In general reduced cover is correlated with increased predation rates (Westman 1991; Holdich, Gydemo and Rogers 1999).

Literature Cited:

Ackerfors, H. 1999. The culture and capture crayfish fisheries in Europe. World Aquaculture 29(2): 18-24, 64-67.

Barbaresi S. & F. Gherardi. 2000. The invasion of the alien crayfish *Procambarus clarkii* in Europe, with particular reference to Italy. Biological Invasions 2: 259-264

Bowen. 2003. Rusty Crayfish factsheet Available: http://www.seagrant.umn.edu/ais/rustycrayfish_invader (March 2008)

Collicut, 1998. Biology of Northern Crayfish, Available: http://www.naturenorth.com/fall/crayfish/Fcray.html (March 2008)

Dean, J.L. 1969. Biology of the crayfish *Orconectes causeyi* and its use for control of aquatic weeds in trout lakes. U.S. Bureau of Sportfisheries and Wildlife, Technical Paper 24.

Gherardi F. and D. M. Holdich (eds.). 1999. Crayfish in Europe as alien species. How to make the best of a bad situation.

Godfrey, L. 2002. UC Pest Management Guidelines . University of California. Available: http://www.ipm.ucdavis.edu/PMG/r682500211.html (March 2008)

Griffiths, S.W., Collen, P. and Armstrong, J.D. 2004. Competition for shelter among over-wintering Signal Crayfish and juvenile Atlantic Salmon, Journal of Fish Biology 65: 436 - 447.

Guan, R.Z. 1994. Burrowing behaviour of the crayfish *Pacifastacus leniusculus* in the River Great Ouse. Freshwater Forum 4, pp. 155–166

Guan, R.Z. and Wiles, P.R. 1997. Home range of the crayfish, *Pacifastacus leniusculus* in a British lowland river. Freshwater Forum 8, pp. 45–54

Gutiérrez-Yurrita P.J.; Montes C. Bioenergetics and phenology of reproduction of the introduced red swamp crayfish, *Procambarus clarkia*. Freshwater Biology, Volume 42, Number 3, November 1999 , pp. 561-574(0)

Gutierrez-Yurrita P.J., G. Sancho, M. A. Bravo, A. Baltanas and C. Montes. 1997. Diet of the Red Swamp Crayfish *Procambarus clarkii* in natural ecosystems of the Donana National Park temporary fresh-water marsh (Spain) Journal of Crustacean Biology, Vol. 18, No. 1 (Feb., 1998), pp. 120-127

Hiley*, P.D.* Conservation Biology 11: 641-647. 2003. The slow quiet invasion of signal crayfish (*Pacifastacus leniusculus*) in England

Holdich, D.M., Gydemo, R. and Rogers, W.D. 1999. A review of possible methods for controlling nuisance populations of alien crayfish. In Gherardi, F. and Holdich, D.M. (eds.) Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A.A. Balkema, Rotterdam, Netherlands: 245-270.

Holdich, D.M. 1999. The negative effects of established crayfish populations. In Herardi, F. and Holdich, D.M. (eds.) Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A.A. Balkema, Rotterdam, Netherlands: 31-48.

Holdich, D.M., Rogers, W.D. and Reynolds, J.D. 1999. Native and alien crayfish in the British Isles. In Gherardi, F. and Holdich, D.M. (eds.) Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A.A. Balkema, Rotterdam, Netherlands: 221-242.

Huner, J. Henttonen. 1999. The introduction of alien species of crayfish in Europe: A historical introduction Crayfish in Europe as Alien Species.

Ilheu, M. and Bernardo, J.M. 1993. Experimental evaluation of food preferences of red swamp crayfish, *Procambarus clarkii*: University of Southwestern Louisiana, LaFayette, LA (USA). pp. 359-364. 1993.

Johnson, J. E. 1986. Inventory of Utah crayfish with notes on current distribution. Great Basin Naturalist. 46: 625-631.

Lewis, S. D. 2002. *Pacifastacus*, in Holdich, D. M. (Ed.), Biology of freshwater crayfish. Blackwell Science, Oxford: 511-540

Lindqvist, O.V. and Huner, J.V. 1999. Life history characteristics of crayfish: What makes some of them good colonizers? In Gherardi, F. and Holdich, D.M. (eds.) Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A.A. Balkema, Rotterdam, Netherlands: 23-31.

NatureServe. 2003. NatureServe Explorer: An online encyclopedia of life [web application].Version 1.8. NatureServe, Arlington, Virginia. Available: http://www.natureserve.org/explorer. (February 2008)

Nystrom, P. 1999a. Ecological impact of introduced and native crayfish on freshwater communities: European perspectives. In Gherardi, F. and Holdich, D.M. (eds.) Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A.A. Balkema, Rotterdam, Netherlands: 63-85.

Nystrom P., C. Bronmark, and W. Graneli-Oikos. 1999b. Influence of an exotic and a native crayfish species on a littoral benthic community: European perspectives. In Gherardi, F. and Holdich, D.M. (eds.) Crustacean Issues 11: Crayfish in Europe as Alien Species (How to make the best of a bad situation?) A.A. Balkema, Rotterdam, Netherlands: 23-31.

Pedigo, L.P. 1989. Entomology and pest management. New York: Macmillan Publishing Co.

Pennak, R. W. 1978. Freshwater invertebrates of the United States. John Wiley and Sons, New York.

Schleifstein, M. and Fedeli, D. 2003. Louisiana crawfish invade ponds across the globe. The Times Picayune: Monday April 14, 2003.

Sibley, P. 2000. Signal crayfish management in the River Wreake catchment, in rogers, D. & Brickland, J. (Eds), Crayfish Conference Leeds. Environment Agency, Leeds: 95-108.

Sibley, P. J. 2003. The distribution of crayfish in Britain, in Holdich, D. M. & Sibley, P. J. (Eds), Management & Conservation of Crayfish. Proceedings of a conference held in Nottingham on 7th November, 2002. Environment Agency, Bristol: 64-72.

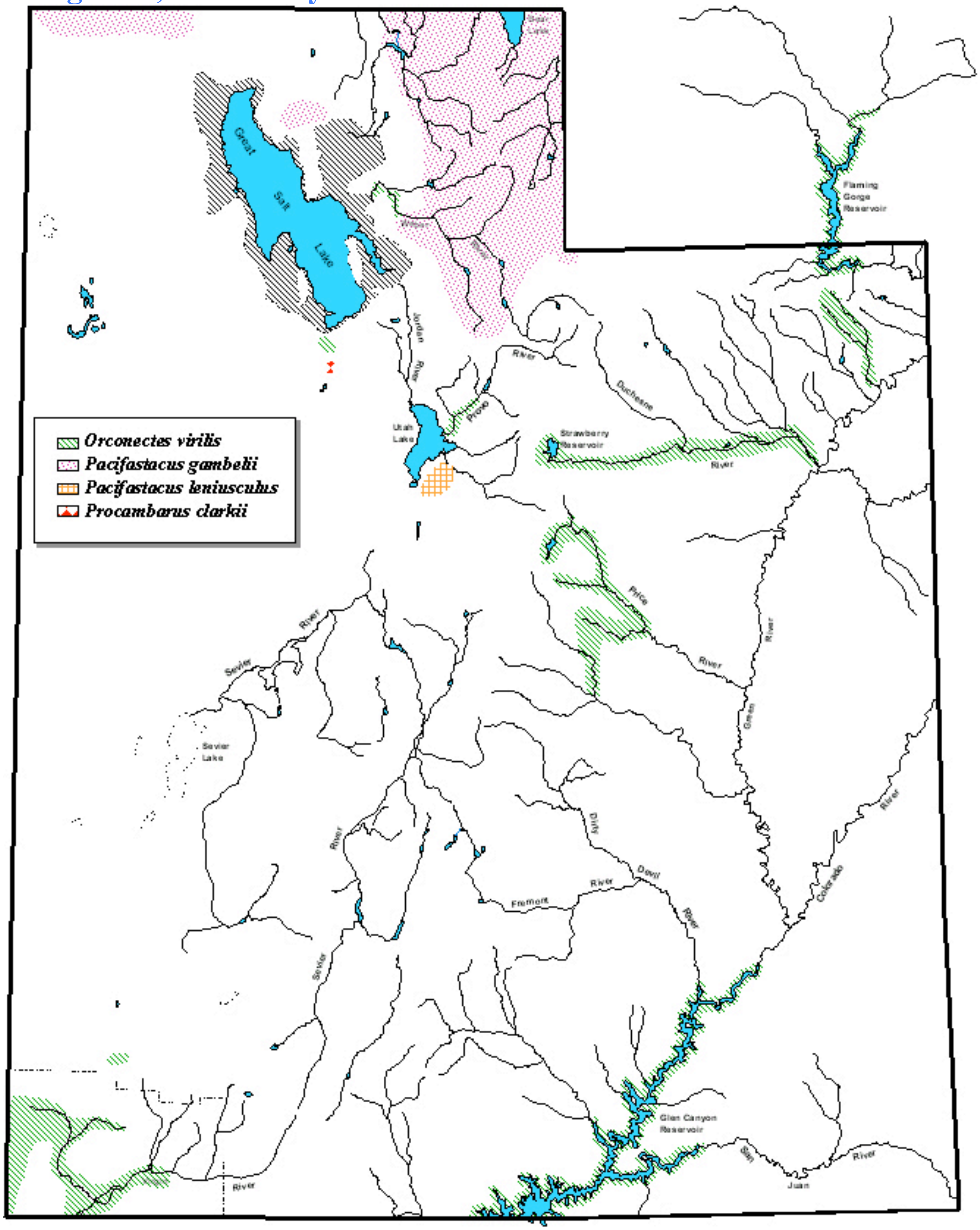
Stebbing, P. D., Bentley, M. G. & Watson, G. J. 2003. Mating behaviour and evidence for a female released courtship pheromone in the signal crayfish *Pacifastacus leniusculus*. Journal of Chemical ecology 29 (2): 463-473.

Thune, R.L., Hawke, J.P., & Siebling, R.J. 1991. Vibriosis in red swamp crayfish Journal of Aquaculture, Animal Health. 3:188-191.

Washington Department of Fish and Wildlife. 2003. Prohibited aquatic animal species: *Procambarus clarkii*. Washington Department of Fish and Wildlife's Aquatic Nuisance Species Classification.

Westman, K. 1991. The crayfish fishery in Finland - its past, present and future. Finn. Fish. Res. 12:187-216.

Figure 1, Utah Crayfish Distribution



Johnson, J. E. 1986.